Institute of Nanoscience and Nanotechnology of the University of *Barcelona* (IN^{2}UB)*

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A thorough understanding of the behaviour of matter at both the atomic and the molecular scales is possible nowadays thanks to the wide background of theories and models existing to this end. This is also true of the behaviour of matter at microscopic level. There is, however, an entire field yet to be explored just in the middle, where systems present dimensions of about, or below, 100 nanometers. A wide range of properties having their origins in the processes which take place in such scale lengths can be modified just by controlling the structure of systems at nanometric scale. The manufacturing and the study of nanosystems which may offer alternative functional properties are therefore the biggest challenges which nanoscience and nanotechnology set before us today. We can face these challenges guided by the deep knowledge we already have of these disciplines and with the help of a large choice of methodologies.

The great expectations existing nowadays about the application of new technologies based on the development of nanostructured materials, as well as of new tools aimed at an accurate handling of the nanoscale, have pebbled the way for a research field which is now experiencing a decisive growth: nanotechnology. The various applications of nanotechnology can be seen and felt each day with higher intensity, and its impact on everyday life shall not definitely stop growing in the near future. Nanotechnology can in fact be applied to almost every field of research nowadays and, without doubt, it shall be at the basis of most technologies of the future.

Research institutes are, nowadays, one of the most significative organizational units of research, created to encourage research and to promote its outcome within society. Many public administrations and other official bodies worldwide organize research and development activities in the field of Nanotechnology by creating specialised research institutes. With the will of following such organizational pattern, the University of Barcelona created in 2006 the Institute of Nanoscience and Nanotechnology (IN^{2}UB), which as an aim to coordinate multidisciplinary research activities carried out by several research groups of this institution. The IN^{2}UB wants to contribute to the progress of science and innovation while spurring, at the same time, industrial excellence. Researchers who are members of the IN^{2}UB come from different scientific disciplines, such as Physics, Chemistry, Pharmacy Science, Biochemistry and Medicine. In this framework, the IN^{2}UB aims at promoting, both internally and internationally, the collaboration among different groups and research centers by strengthening interdisciplinary activities which integrate both basic and applied research. The IN^{2}UB is thus participating in national strategic programs and in several international projects and actions as well.

The IN^{2}UB is located at the Pedralbes campus of the *Universitat de Barcelona* in the south of the city. It integrates 35 research groups from the Faculties of Physics, Chemistry, Pharmacy Science, Medicine and from the Scientific Park of Barcelona. The number of academic staff and pre-doctoral students doing research within IN^{2}UB is of 160 and 180, respectively. Post-doctoral researchers and visitors are about 50 people.

Moreover, the *Universitat de Barcelona* leads the Master in Nanoscience and Nanotechnology, in cooperation with the *Universitat Rovira i Virgili* (Tarragona), the *Universitat Politècnica de Catalunya* (Barcelona) and the *Universitat de Girona* within the Bologna policy framework. It aims at providing students with a deep and oriented formation in the field of the nanoscience and nanotechnology. Teaching is based on research activity, transfer of knowledge and the sharing of experiences and procedures. The academic staff belonging to the IN^{2}UB has a most singular role in the teaching activities.

The institute gathers six different research areas, each of which comprehends several specific research lines, which can be outlined as follows:

1. Modelling and Simulation of Systems and Properties of Matter in the Nanoscale

The theoretic simulation of real systems by means of several techniques derived from Quantum Mechanics must enable researchers to predict the properties of new materials under development. This predictive quality is essential in the creation of theoretic models, so that these can be applied successfully to

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confined quantum gases, or to such fields as photonics, optoelectronics, molecular motors, catalysis and magneto-optics. On the other hand, the theoretic, idealised models that are to replace the much more complex systems we find in reality must prove useful when it comes to the general comprehension of whatever phenomena are under study. These models must also be of help in the establishment of general rules which can guide specialists further in the design of new systems. This area comprehends the following research lines:

A. Transport and Conduction
B. Surface Effects
C. Electronic Structure and Excitations
D. Bose-Einstein Condensates and Quantum Confined Gases

2. Nanobiotechnology

This research area covers the study of the organizational patterns observable in the molecular structures which control and rule the biological systems (both) at the cellular and the molecular scales. Nanobiotechnology focuses also in the analysis of the interaction existing between materials and these molecular systems at nanometric scale. Its most relevant application is that of developing techniques and devices aimed at prevention and diagnose in nanomedicine. Nanobiotechnology is also useful as far as the development of new therapeutic techniques is concerned. It comprehends the following research lines:

A. Functionalisation of Surfaces
B. Cellular and Molecular Biomechanics
C. Biomimetic Structures and Systems
D. Nanofluidics and Nanorobotics. Nanomotors
E. Diagnosis in Nanomedicine: Marking and Molecular Observation
F. Nanobiosensors; DNA Chips and Proteins; Lab on Chip

3. Nanopharmacotherapy

Nanopharmacotherapy focuses on the development of nanostructured systems aimed at improving the drug released control methodologies already existing. One of the main challenges for the researchers working in this area is to reach the highest rates of therapeutic effectiveness in the treatment of target organs in order to reduce the toxicity of drugs in healthy tissues. In the field of genic therapy, there is a special interest in the targeted delivery of plasmids as non viral vectors. It covers the following research lines:

A. Nanostructured Systems for Drug Released Control. Nanoencapsulation
B. Interactions between Nanostructured Systems and Biologic Structures
C. Bioavailability, Toxicity and Therapeutic Effectiveness of Nanostructured Systems

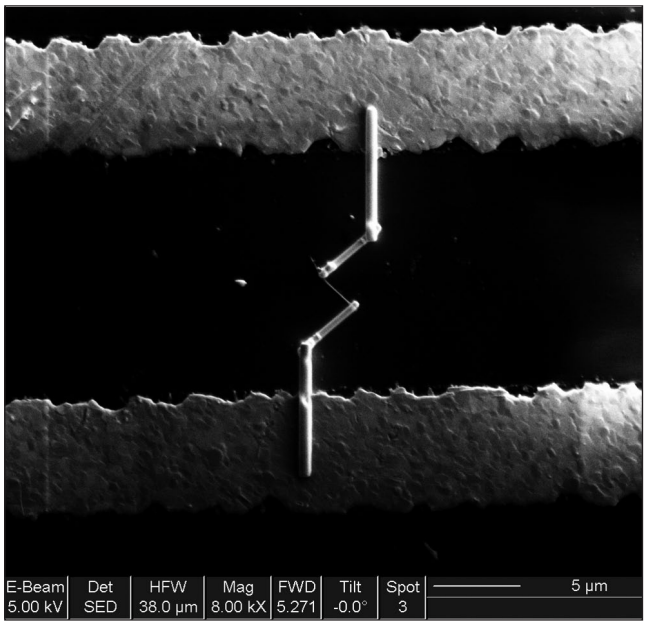

Figure 1. Nanowire of tin oxide contacting two gold microelectrodes which has been manufactured by using FIB nanolithography. This nanodevice is integrated with the electronics necessary to operate as a portable gas sensor. A microheater permits the regeneration of the sensor in a rapid and repetitive manner. This picture has appeared as the cover of Nanotechnology 18, number 49, 12 December 2007.

D. Genic Therapy; Non Viral Vectors. Pharmacogenomics and Nutrigenomics
E. Molecular Internalisation and Molecular Marking. Detoxification

4. Nano-TIC: nanomagnetism, nanoelectronics, and nanophotonics

Research in this area focuses mainly on the development of new systems for storage and processing of information at nanoscopic scale. It also focuses on the study of new phenomena related to nanometric size. The interrelations among electronic, magnetic and/or optical properties within a nanosystem allows for the design of materials and devices with new functionalities. Figure 1 shows and example of a nanodevice recently developed. This area covers the following research lines:

A. Magnetic Nanoparticles and Unimolecular Magnets
B. Dynamical Processes in Nanomagnetism. Microwave Interactions
C. Magnetoelectronics
D. NEMS (Nanoelectromechanical Systems)
E. Nanodevices, Nanosensors; Electronics, Optoelectronics, and Photonic Nanosystems. Photonic Crystals

5. Nanostructured materials

This research area aims at the development of new nanomaterials with improved or new properties with respect those of the

bulk counterparts. The development of new technological applications based on materials and systems tailored at nanometer scale and with enhanced properties is one of the main goals of this research activity. This area comprehends the following lines:

A. Synthesis, Nanomanufacture and Nanomanipulation
B. Thin Films, Multilayers and Coatings
C. Nanoparticles, Gels, Nanofibers, Nanorods and Nanotubes
D. Nanostructured Metallic Oxides
E. Nanocompounds
F. Mesoporous Materials and Nanotemplates

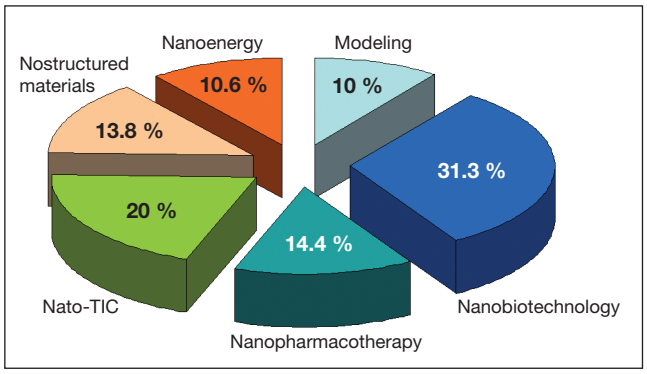

Figure 2. Percentage distribution of researchers within the six research areas of the institute.

6. Nanoenergy: production, storage and environment

This area focuses on the research about nanomaterials applied to the production, the storage and the use of energy with the purpose of improving the duration and the efficiency of resources, which should translate later on in energy saving. Researchers strive to find more competitive and environmental friendly methods for energy production and storage. This research area covers the following lines:

A. Catalytic Nanostructures for Energy Production; Fuel Cells
B. Nanomaterials for Solar Cells; Photocatalytic Processes
C. Nanostructured Systems for Energy Storage
D. Functional Nanotubes and Nanorods
E. Pollution and Gas Detection Nanosensors

Figure 2 shows the percentage distribution of researchers within these six research lines. It is worth noting that research activities on the applications of Nanotechnology to Biomedicine represents about the 50 percent of the total, and the research in which is called hard nanostructured materials is the rest of the activity.

A list of the most relevant infrastructures available to the groups doing research in the fields of Nanoscience and Nanotechnologies at the *Universitat de Barcelona* follows:

- Nanosynthesis through Chemical Routes
- Equipments for Thin Film and Nanometric Materials Growth (CVD, PECVD, Cathodic Sputtering, Laser Ablation, HFCVD); Surface Analysis
- Tribological and Mechanical Characterisation (Nanoindenter)
- Magnetometry; Microwave Spectroscopy; Optical and Electrical Characterisation
- Electrodeposition Laboratory
- Cellular Nanoindenter; Nanohandlers: Optical and Magnetic Tweezers
- Techniques for the determination of Particle Size and Zeta Potential
- Infrared, UV-Vis and Mass Spectroscopies; Liquid and Gas Chromatography
- Magnetic and Atomic force Microscopies

Nanotechnology Platform at the *Parc Científic de Barcelona*

- Focussed Ion Beam, Hot Embossing, and Nanoimprint Lithography; Reactive Ion Etching
- Molecular Force Probe; Atomic Force Microscopy with Local Conductance

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- Surface Analysis (XPS, Auger electrons)
- X-Ray Difraction
- Scanning Electronic Microscopy
- Electronic Microscopy of High Resolution; Energy Loss Spectrometer (EELS)